Modular RICH Detector

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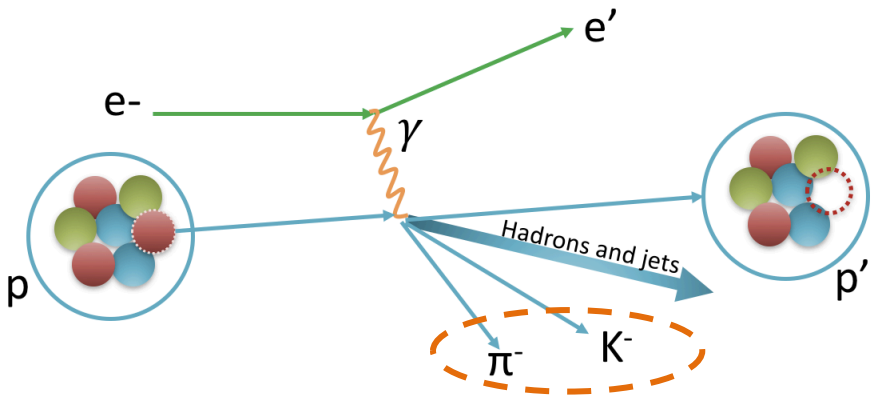
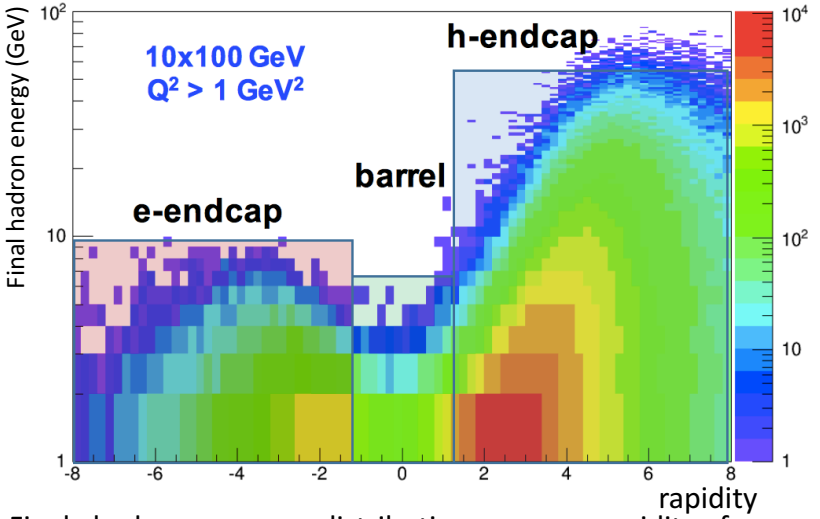
04-24-2017

Outline

- Electron-Ion Collider Experiment
- mRICH Detector
- mRICH in sPHENIX simulation

Semi-Inclusive Deep Inelastic Scattering Measurement in EIC Experiment

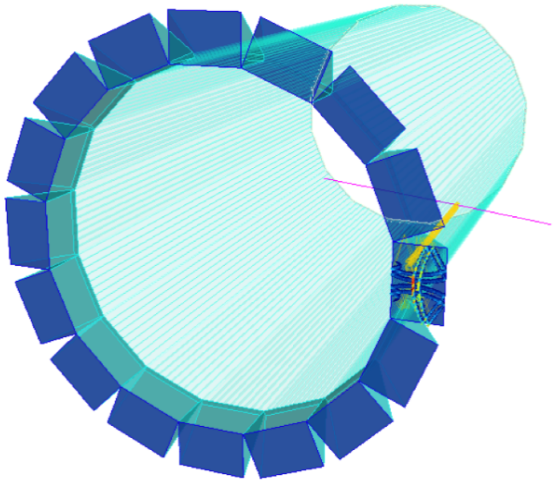




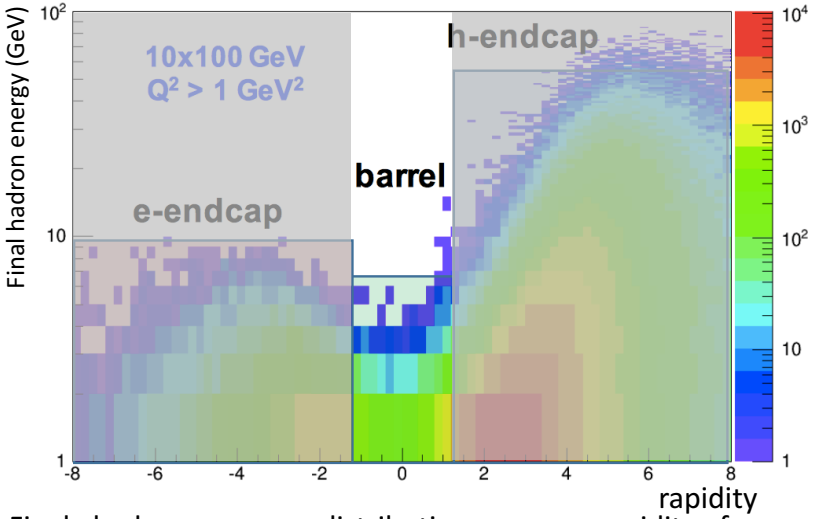
Final hadron energy distribution versus rapidity from proton (10 GeV/c)-electron (100 GeV/c) collision Pythia simulation

- Obtain gluon and quarks distribution in spatial, momentum, spin spaces from transverse momentum of final hadrons, kaon and pion.
- K^- $(s\bar{u})$ from final $\phi(s\bar{s})$ decay
  → strange sea quarks distribution inside nucleon

Charged Hadron PID in EIC Experiment



Detection of internally reflected Cherenkov light (DIRC) Detector



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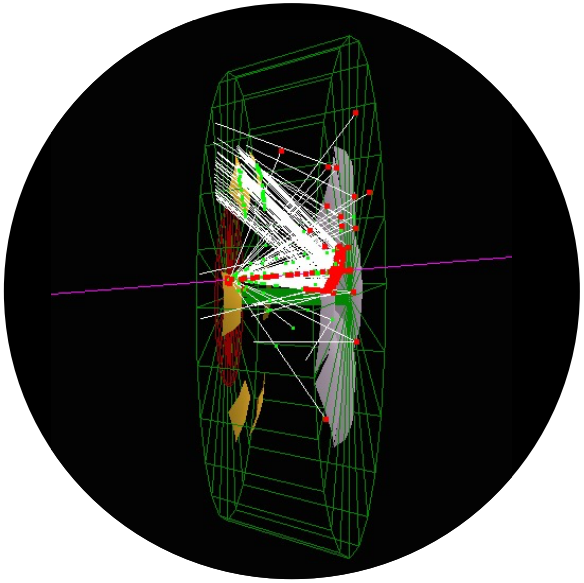
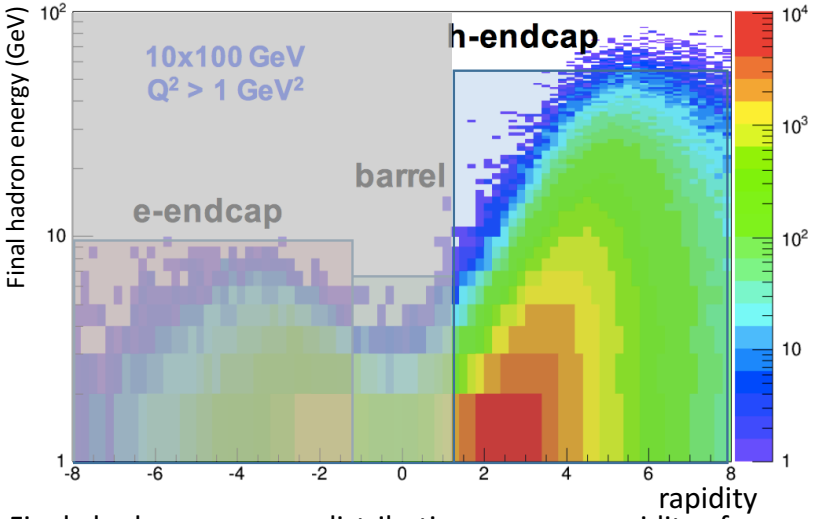


Dual Radiator RICH (dRICH) Detector



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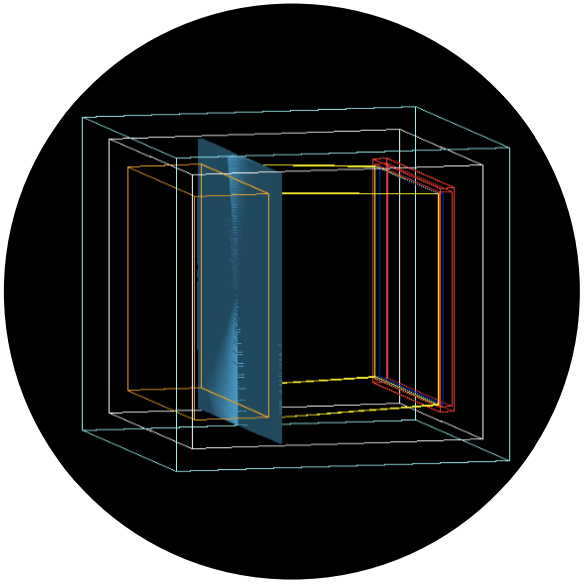
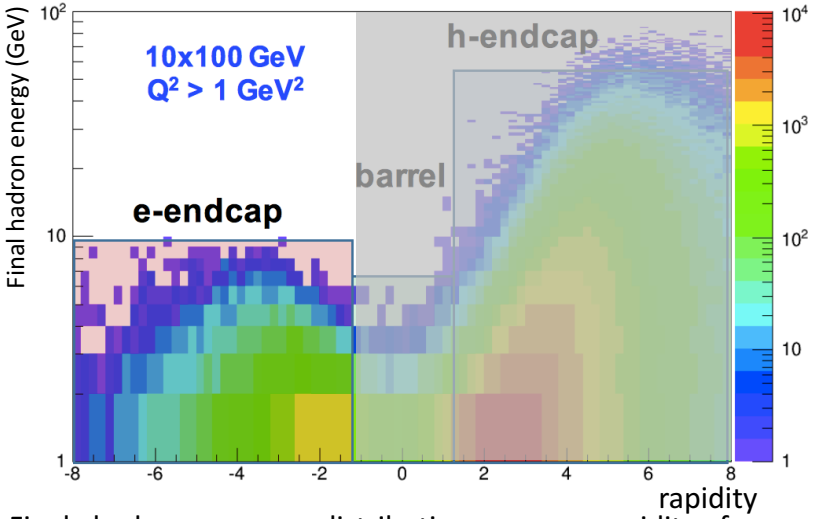


Modular RICH (mRIHC) Detector



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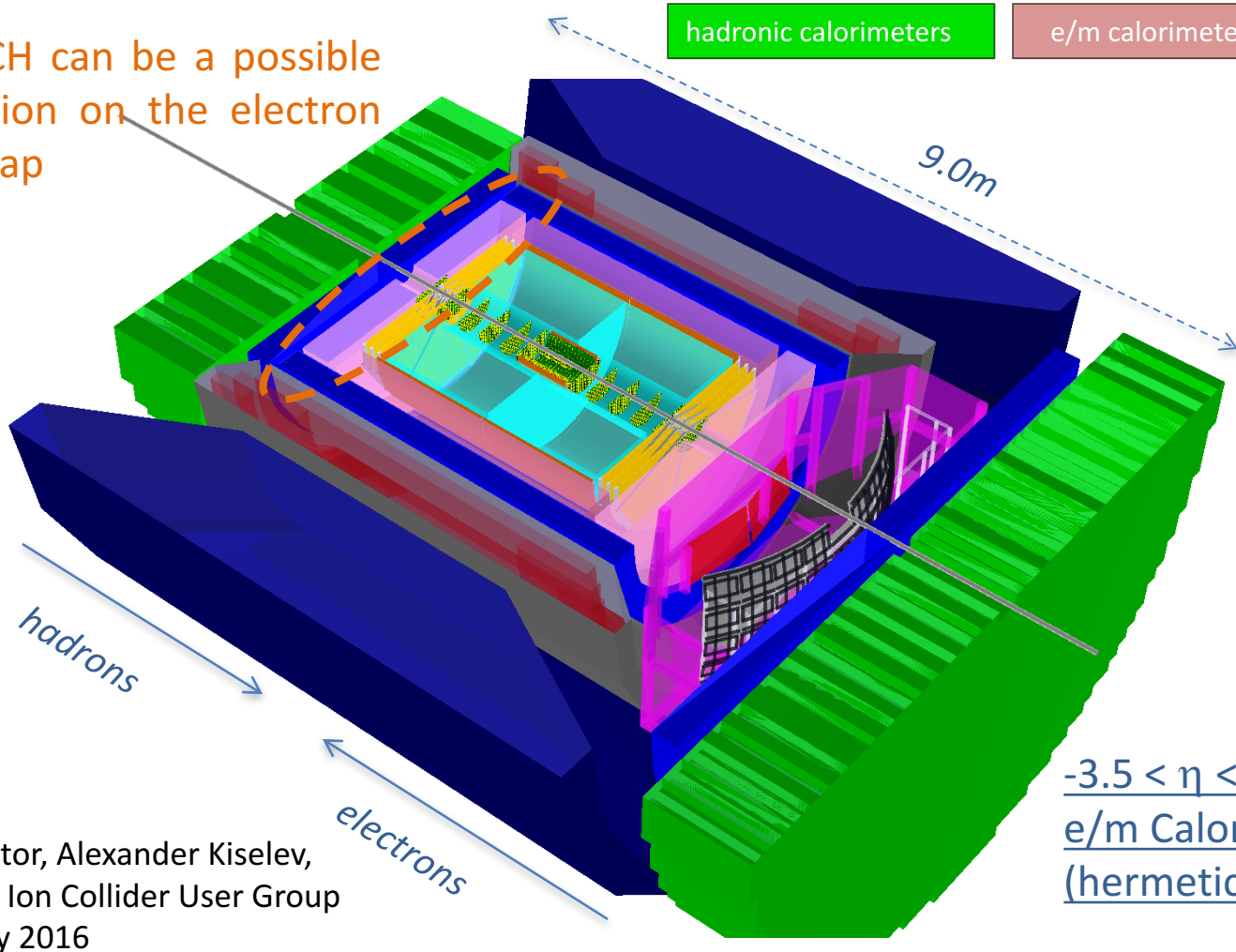
EIC Detector Design: BeAST from BNL

mRICH can be a possible solution on the electron endcap

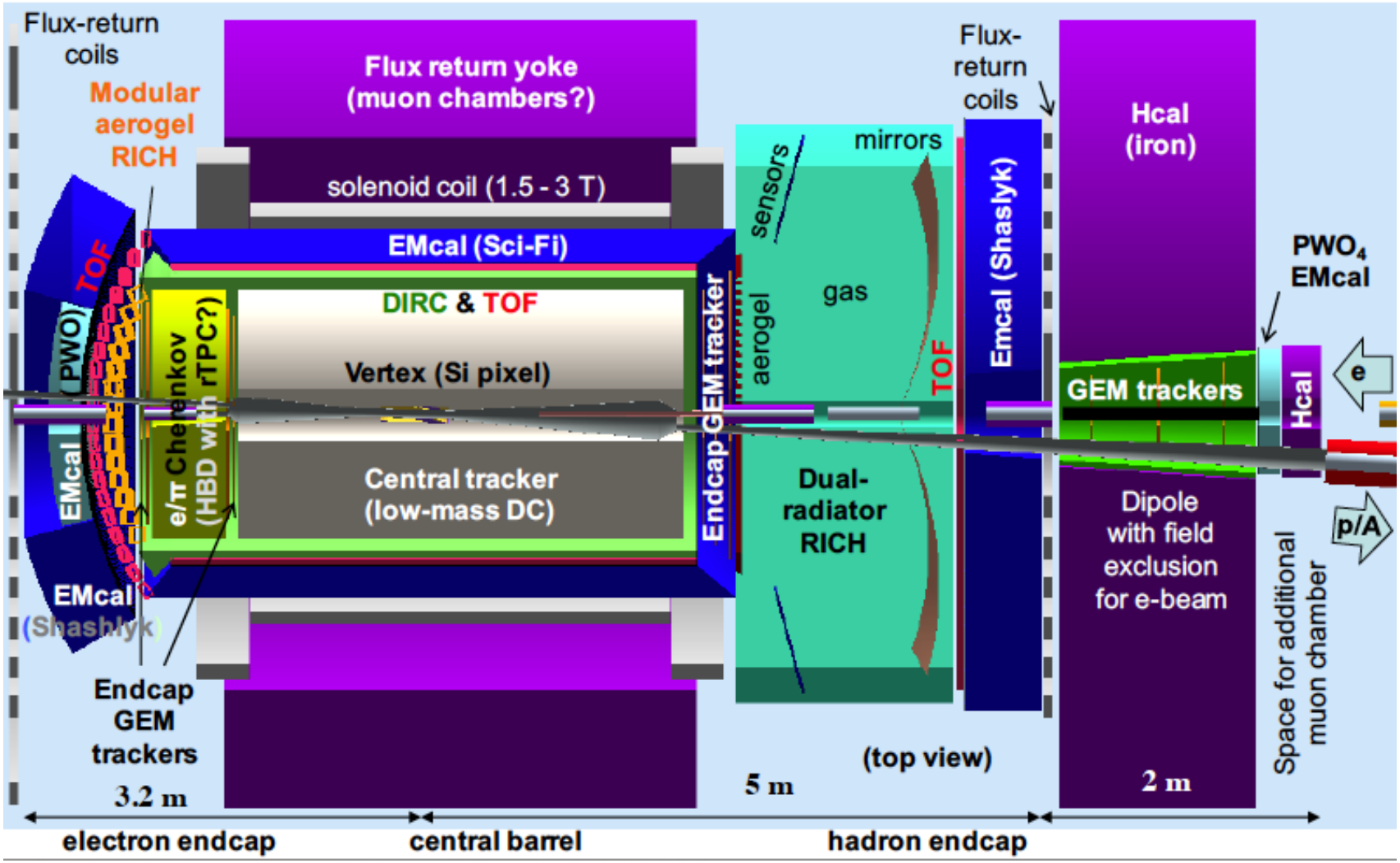


-3.5 < η < 3.5: Tracking & e/m Calorimetry (hermetic coverage)

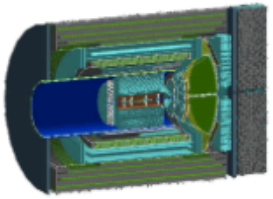
BeAST Detector, Alexander Kiselev, The Electron Ion Collider User Group Meeting, July 2016

silicon trackers | TPC | GEM trackers | Micromegas barrels | 3T solenoid cryostat | magnet yoke

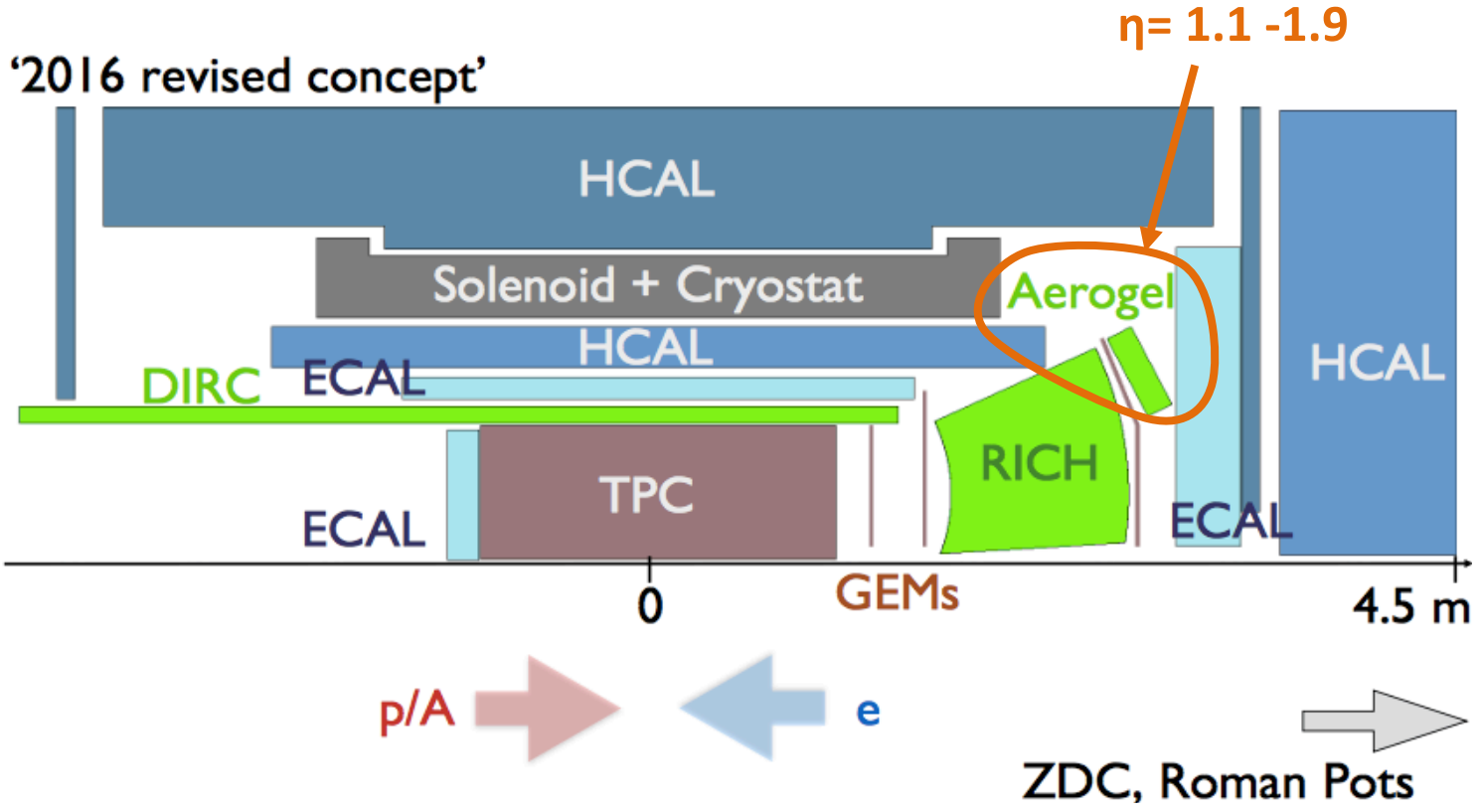
EIC Detector Design : MEIC / JLEIC from JLab



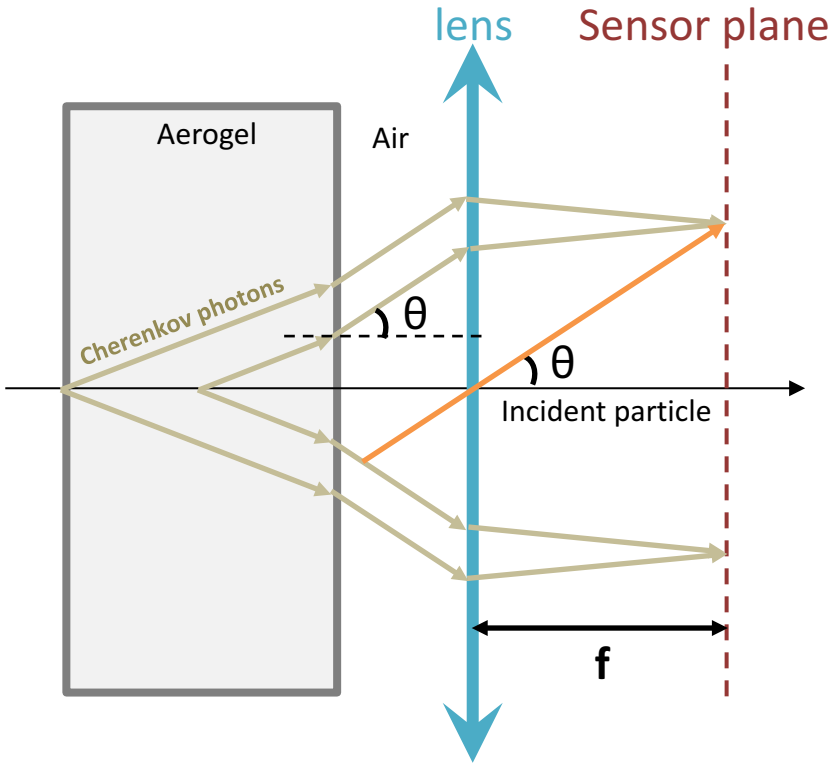
However, EIC is >10 years away

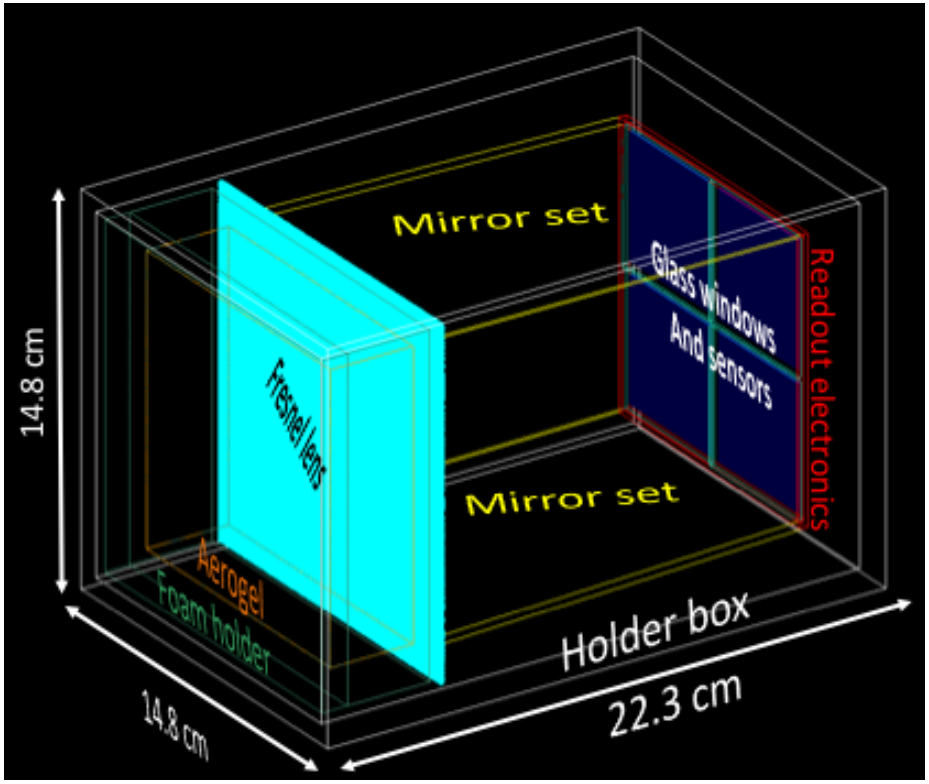


EIC Detector Concept



Design of Modular RICH Prototype

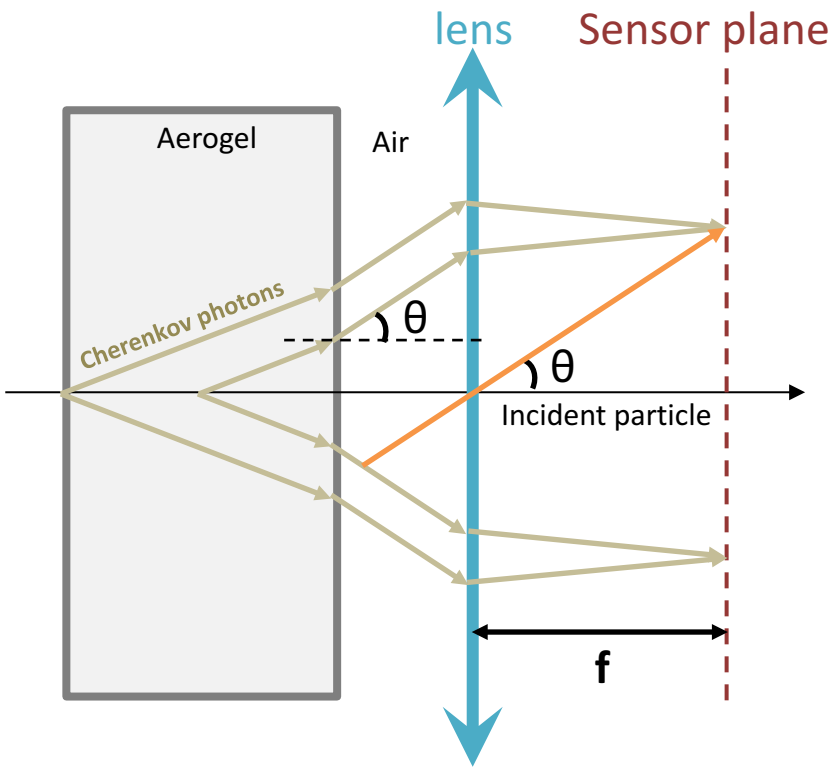


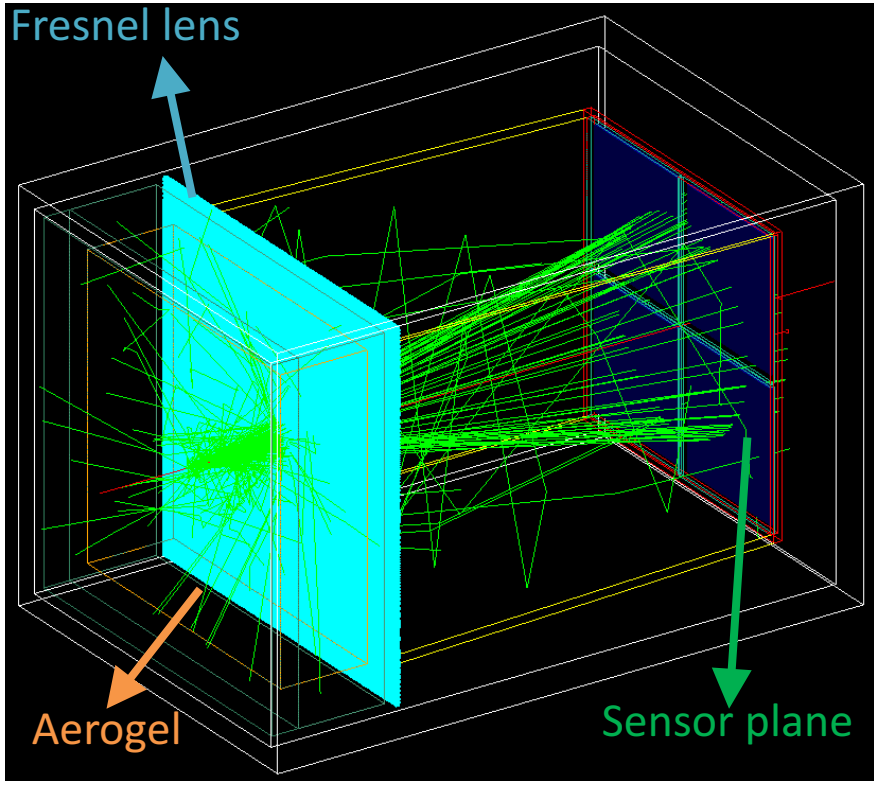


Since parallel rays are focused at the same point, emission point uncertainty which is raised by thickness of aerogel is minimized

Detector layout shown in Geant4 simulation

Design of Modular RICH Prototype





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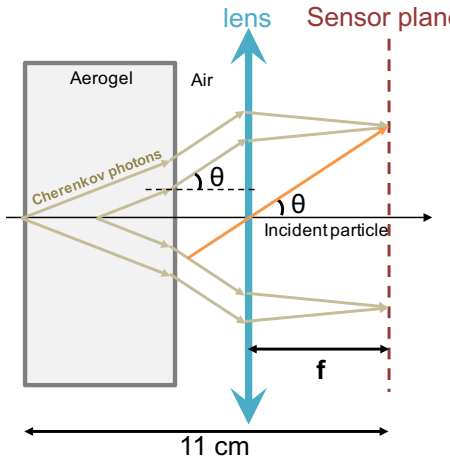
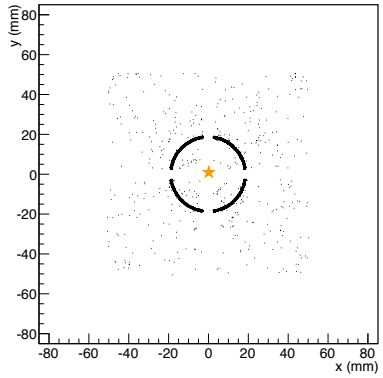
Simulation of single 9 GeV pion . The incident pion emitted Cherenkov photons inside the aerogel. These Cherenkov photons were then focused on the sensor plane

Focusing Property of Lens-Based mRICH Design

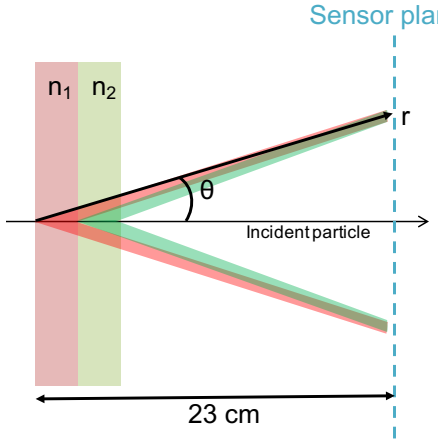
Lens-Based mRICH Design

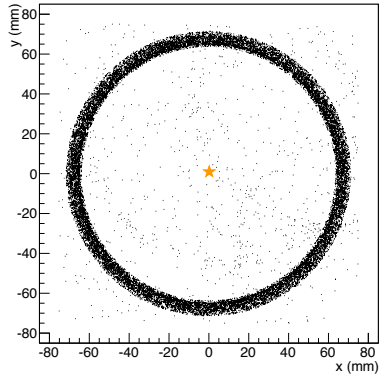




- 9GeV/c pion beam launched at the center of xy plane in simulation
- **Smaller and thinner** ring image

Two-Layer Proximity Focusing Design (BELLE-2 ARICH)

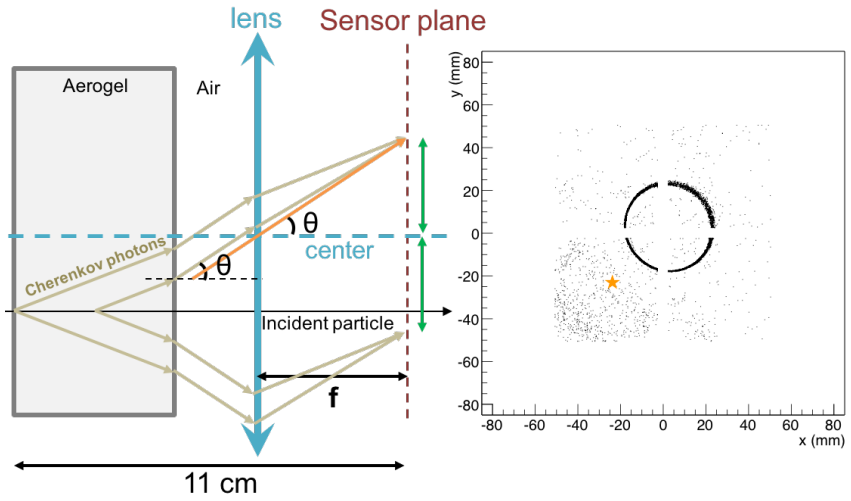




- 9GeV/c pion beam at the center of xy plane in simulation
- BELLE-2 ARICH design aims to separate pion and kaon up to 4 GeV/c

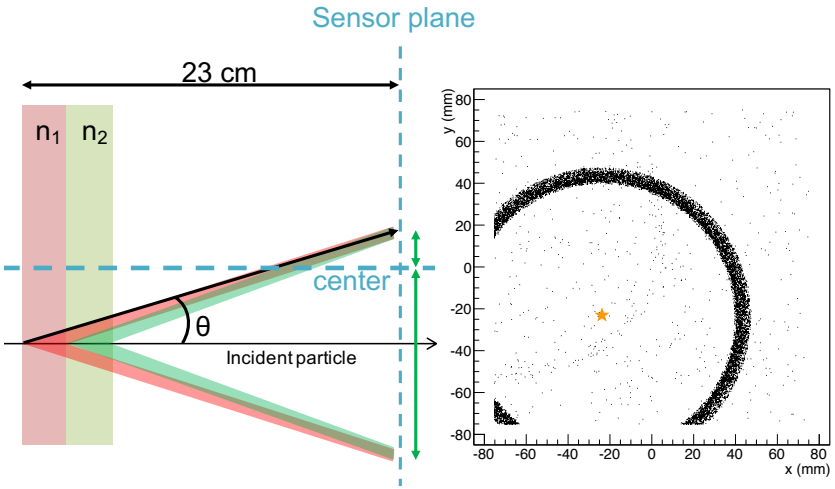
Shifting Property of Lens-Based mRICH Design

Lens-Based mRICH Design



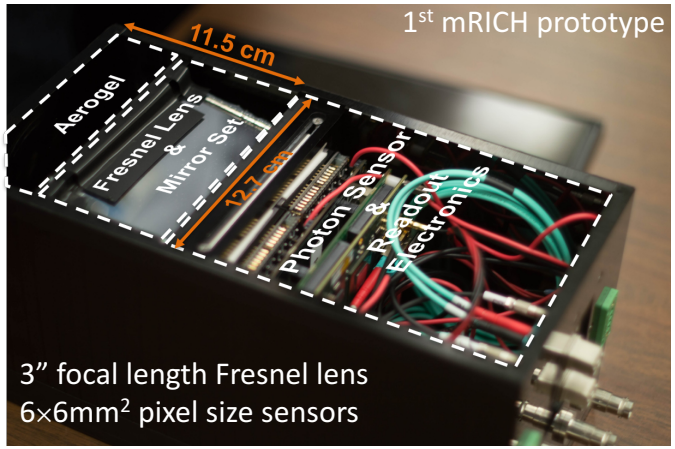
- 9GeV/c pion beam incidents at third quadrant (star) in simulation
- Ring image is sit at **center area** of the sensor plane

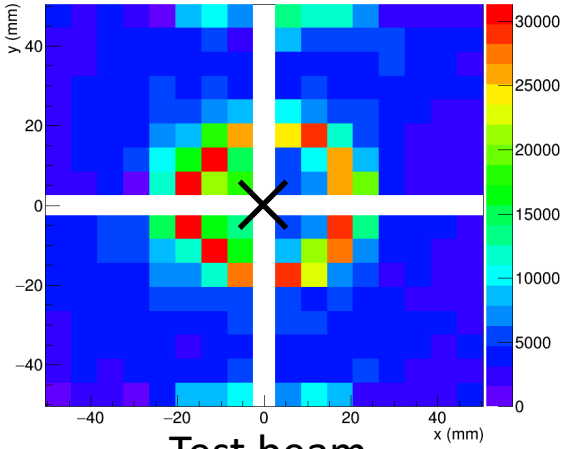
Two-Layer Proximity Focusing Design (BELLE-2 ARICH)



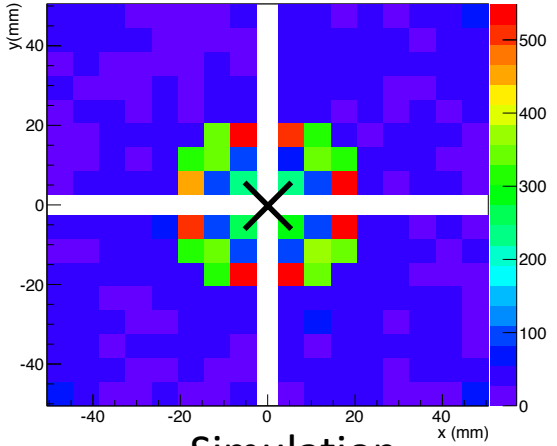
- 9GeV/c pion beam incidents at third quadrant (star) in simulation
- Ring centered at the third quadrant of the sensor plane

1st Test Beam Results





Test beam



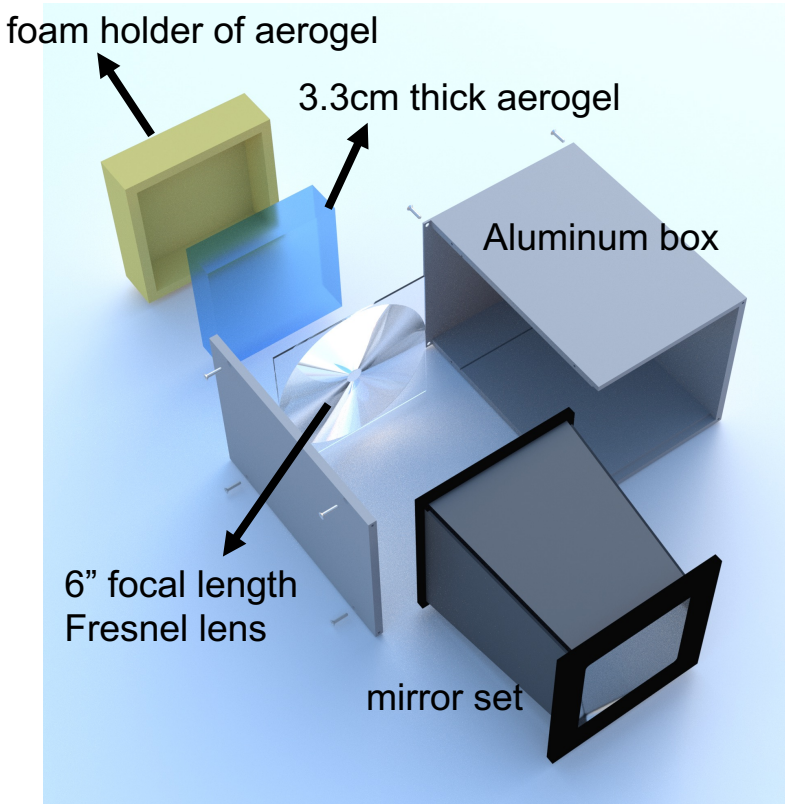
Simulation

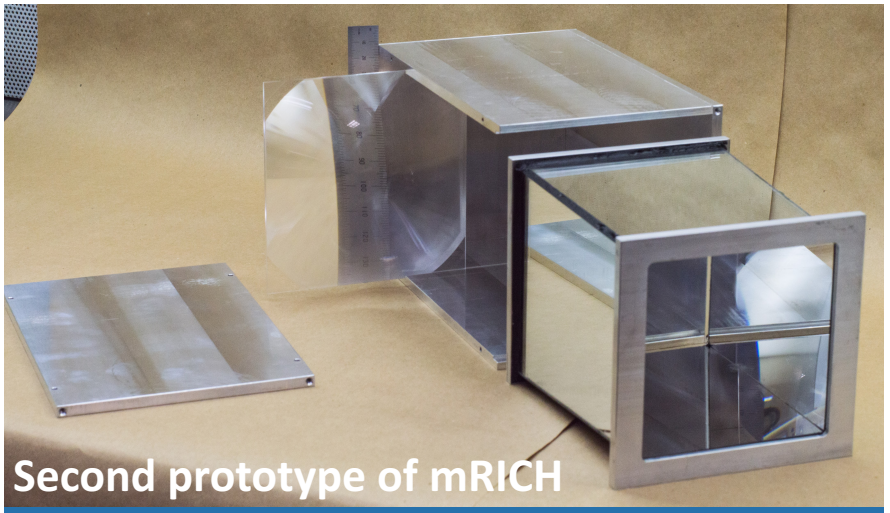
	Analytical Calculation	Test Beam Data	Simulation
Radius (mm)	19.4	19.0 ± 1.3	18.9 ± 1.0
Number of detected photons per event	10.4	11.0 ± 2.9	11.1 ± 2.9

- **The 1st test beam result verified mRICH working principle and validated simulation**
- Paper was submitted to NIM A after first reviewers comments.

Second Prototype

Next beam test in spring 2018 to study PID performance





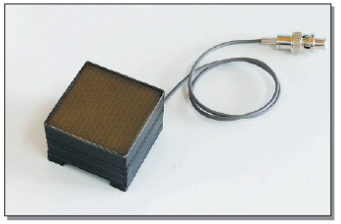
TECHNICAL INFORMATION

OCT. 2016

FLAT PANEL TYPE MULTIANODE PMT ASSEMBLY
H13700 SERIES

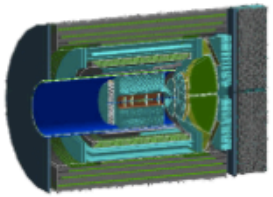
FEATURES

- High quantum efficiency: 33 % typ.
- High collection efficiency: 80 % typ.
- Single photon peaks detectable at every anode (pixel)
- Wide effective area: 48.5 mm × 48.5 mm
- 16 × 16 multianode, pixel size: 3 mm × 3 mm / anode



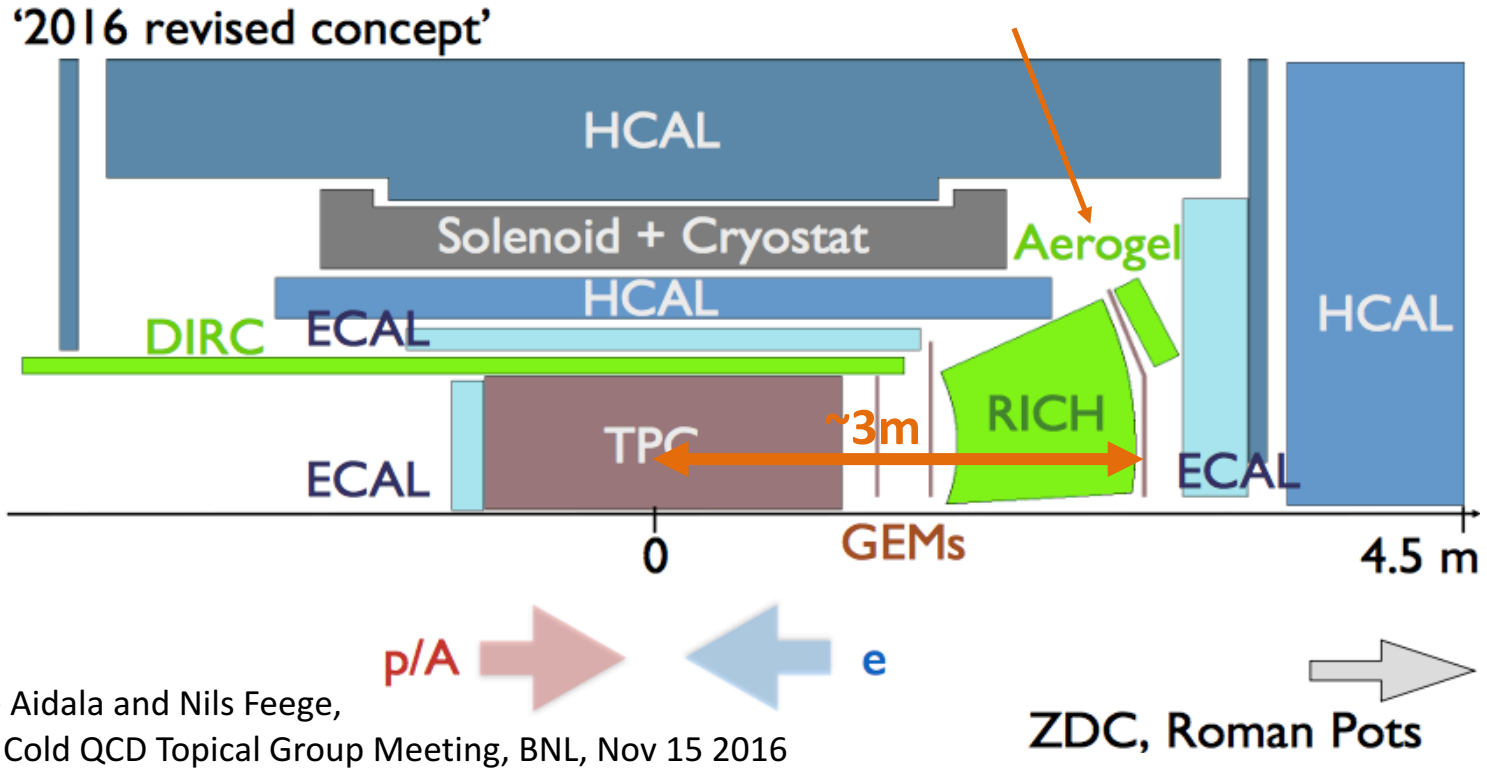
Longer focal length Fresnel lens and smaller pixel size sensors will be used to enhance detector PID performance

fsPHENIX Design



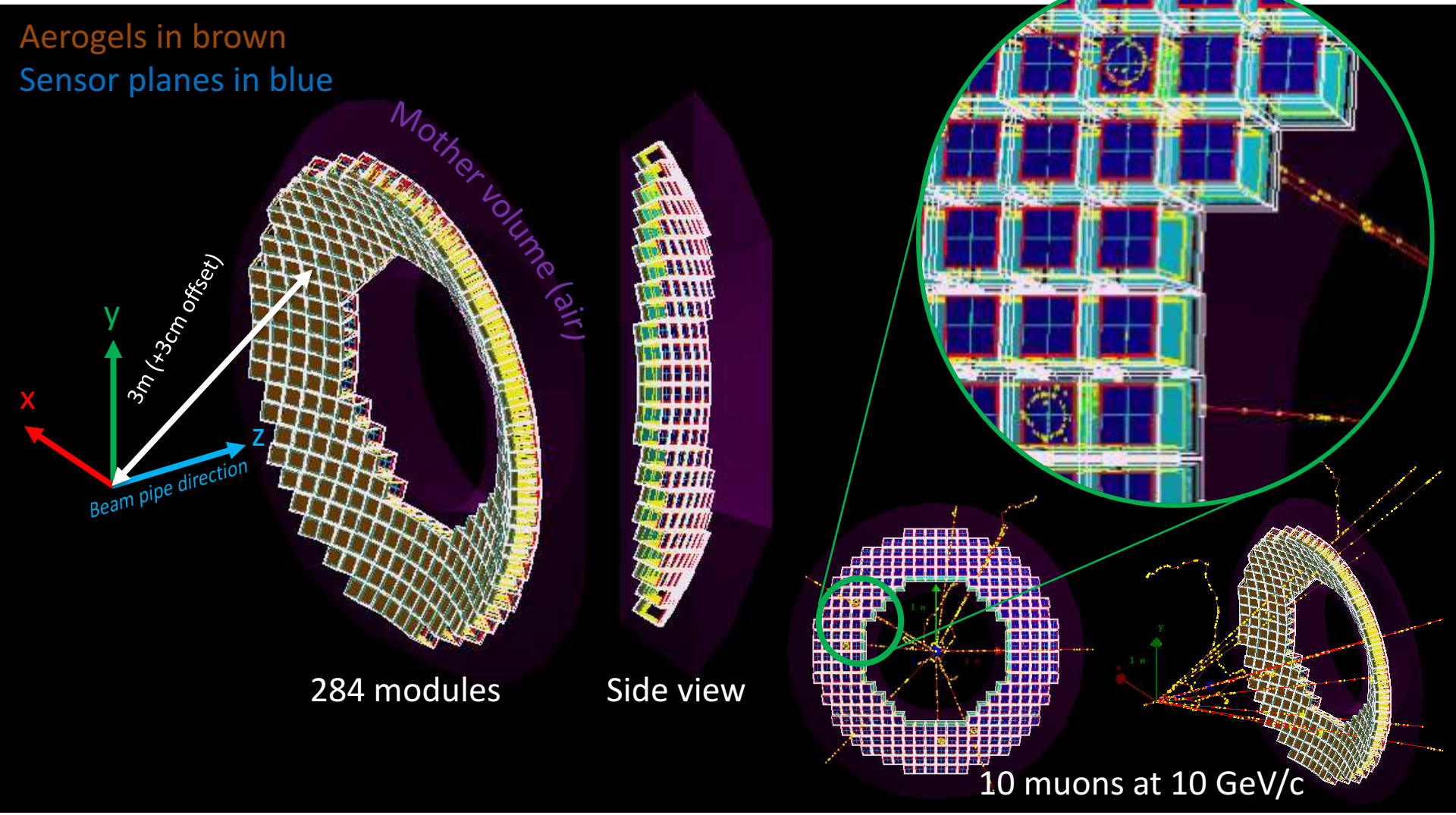
EIC Detector Concept

Rapidity coverage : 1.1 – 1.9



Christine Aidala and Nils Feege,
sPHENIX Cold QCD Topical Group Meeting, BNL, Nov 15 2016

mRICH Wall in sPHENIX Simulation



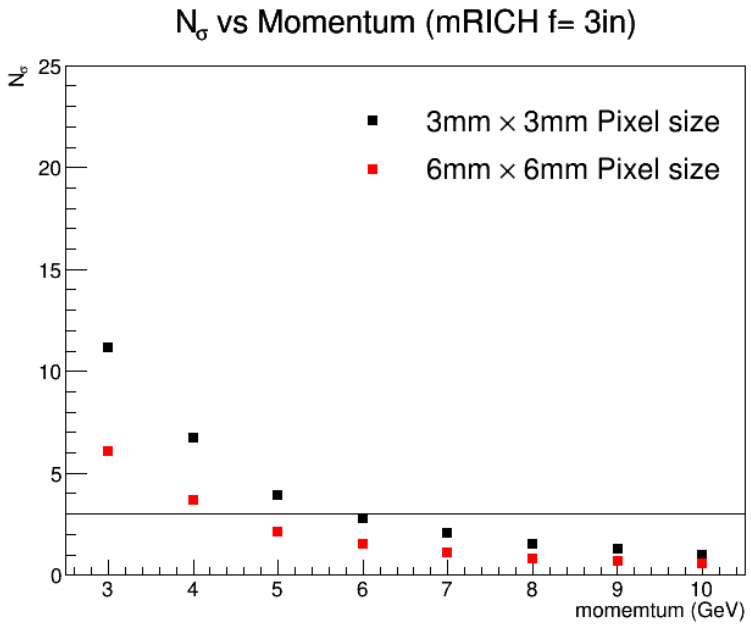
Next

- Commit simulation code to sPHENIX coresoftware repository on Github
- Run Pythia with magnetic field effect

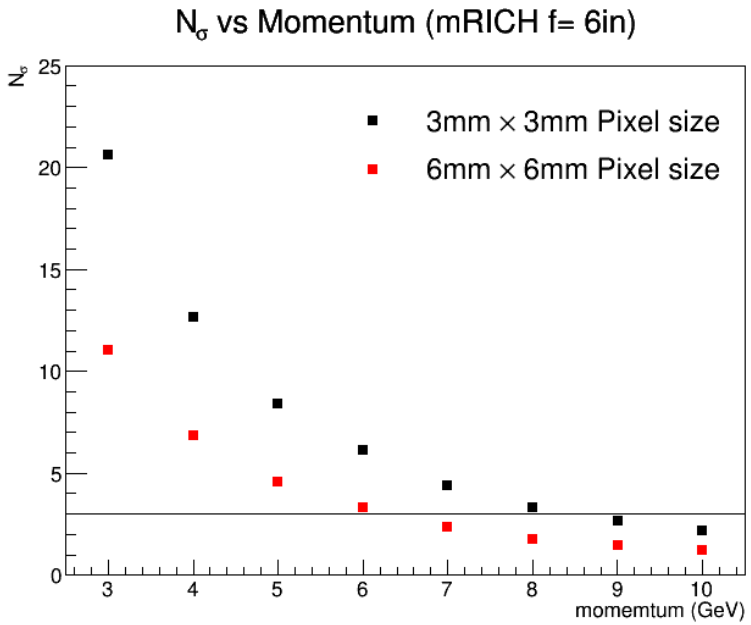
Back Up

mRICH Separation Power with Diff. Focal Length Fresnel Lens Set Up

3-inch Focal length Fresnel lenss

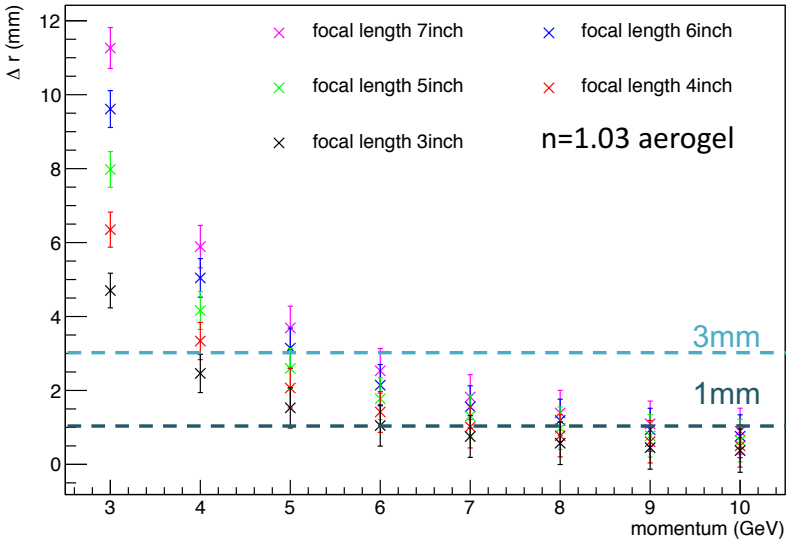


6-inch Focal length Fresnel lenss

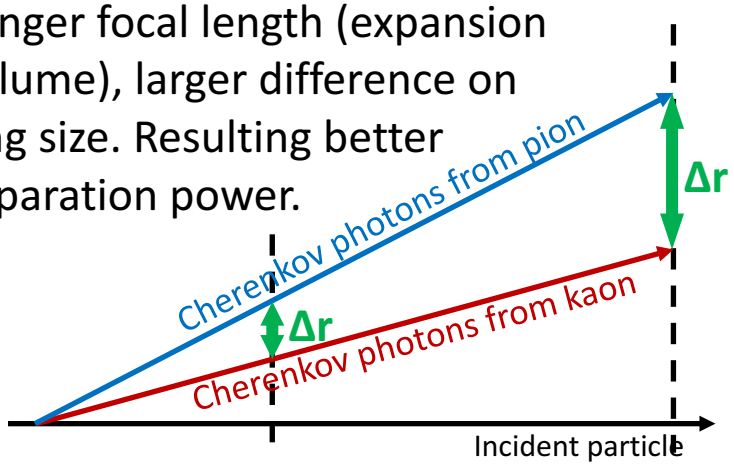


Optimization on Detector Design

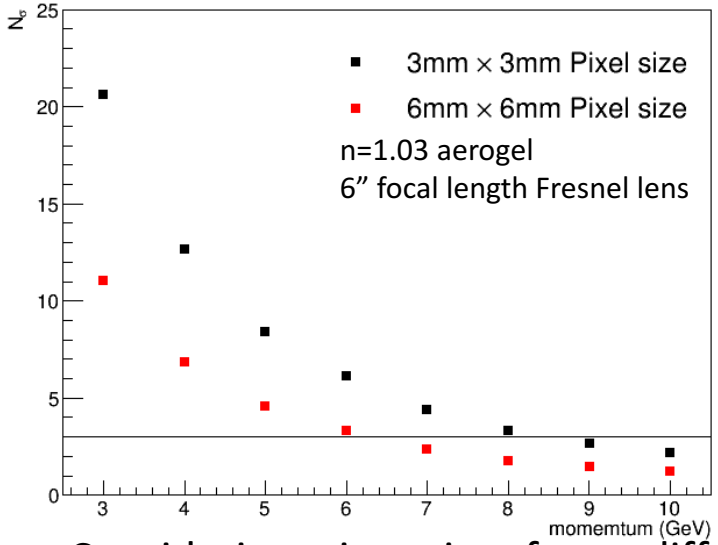
1. Longer focal length Fresnel lens



Longer focal length (expansion volume), larger difference on ring size. Resulting better separation power.



2. Smaller pixel size sensors



- Considering ring size from different focal lengths, 6" focal length Fresnel lens (gives r≈38mm at 10GeV/c) is suggested for 2nd mRICH prototype design
- 3×3mm^2 pixel size sensor is also suggested to increase PID performance in high momentum region